CRITICAL PROPERTIES OF T. G. S. AND R. S. AS DETERMINED BY a d. c. ELECTRIC FIELD METHOD
A. Levstik, M. Burgar, R. Blinc

To cite this version:

HAL Id: jpa-00215017
https://hal.archives-ouvertes.fr/jpa-00215017
Submitted on 1 Jan 1972

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
CRITICAL PROPERTIES OF T. G. S. AND R. S. AS DETERMINED BY A D. C. ELECTRIC FIELD METHOD

A. LEVSTIK, M. BURGAR and R. BLINC
Institute "J. Stefan" Ljubljana, University of Ljubljana, Yugoslavia

Résumé. — La dépendance de la polarisation sur la température en présence d’un champ électrique statique, a été mesurée pour les diélectriques ferroélectriques de sulfate de triglycine T. G. S. et de sel de Rochelle R. S. De même le coefficient critique β a été mesuré.

Les résultats sont en accord avec ceux fournis par la théorie des champs moyens, ceci pour $\varepsilon = \left( \frac{T_c - T}{T_c} \right) \geq 1.2 \times 10^{-4}$ pour T. G. S. et $\varepsilon \geq 2.4 \times 10^{-3}$ pour R. S. Des écarts à la théorie ont été observés pour des valeurs de $\varepsilon$ inférieures à celles données ci-dessus.

Abstract. — The dependence of the polarization on the temperature under the influence of a constant electric field has been measured for ferroelectric triglycinesulfate (T. G. S.) and Rochelle salt (R. S.), and the critical exponent $\beta$ has been determined. The results are consistent with the prediction of the mean field theory for $\varepsilon = \left( \frac{T_c - T}{T_c} \right)$ up to $1.2 \times 10^{-4}$ in T. G. S. and $\varepsilon \geq 2.4 \times 10^{-3}$ in R. S. Below these values of $\varepsilon$ deviations from the mean field theory were observed.

When measuring critical properties of ferroelectric crystals under an a. c. electric field, the determination of critical exponents is influenced by the magnitude of the electric field and the electrocaloric effect. At temperatures very close to $T_c$ the error in the measurements of the spontaneous polarization increases and it is impossible to determine the critical exponents of crystals with a small value of polarization like R. S.

When we investigated critical properties of T. G. S. and R. S. under a constant electric field we have used the same circuit as R. E. Oettel [1]. It consists of the sample, parallel to which there is a linear capacitor $C_1$.

The source of the d. c. voltage was a battery or a power supply. The charge transferred to the series capacitor from the sample is proportional to the polarization of the crystal.

$$P = \frac{C_s V_3}{A} = \frac{C_1 V_1}{A}.$$  

The voltage on the series capacitor was measured using a Keithley model 610 C electrometer and recorded on the $y$-axis of a Moseley $x - y$ recorder. On the $x$ axis of the recorder we used the voltage of the battery of four Cu-constantan thermocouples to record the spontaneous polarization as a function of temperature. The sample was in a Dewar and the temperature was varied by a flow of a hot $N_2$.

The sensitivity of the temperature measurement was $\pm 0.005$ °K and precision of the polarization determination was $\pm 1\%$ at $T_c - T = 0.05$ °K. The Curie temperatures $T_c$ were determined from the plot of $P_s^2$ vs. $T$ (Fig. 1, Fig. 2) by extrapolating to $P_s = 0$.

The values are $T_c$ (T. G. S.) = 322.40 ± 0.01 °K and $T_c$ (R. S.) = 297.75 ± 0.02 °K. The absolute value

$$F = F_0 + \frac{1}{2} a P_s^2 + \frac{1}{4} b P_s^4 + \cdots$$  

which predicts

$$P_s^2 = - \frac{a'}{b} = - \frac{a'}{b} (T - T_c)$$  

is correct in T. G. S. up to

$$\varepsilon = \frac{T_c - T}{T_c} = 1.2 \times 10^{-4}.$$
The value of $a'$ obtained from measurement of dielectric constant is $a' e_0 = 4.6 \times 10^{-6} \text{K}^{-1}$. From figure 1 we determine the value of $b$ as

$$b = 7.8 \times 10^{14} \text{Vm}^2 \text{A}^{-3} \text{s}^{-3}.$$

From the log-log plot of $P_s^2$ vs. $T_c - T$ (Fig. 3) for T. G. S. (a) and R. S. (b) the critical exponent $\beta$ which is defined

$$P_s \propto (T_c - T)^\beta$$

(3)

can be determined. From $T_c - T = 1 \text{K}$ to $T_c - T = 0.05 \text{K}$ the data for T. G. S. are in agreement with the classical value $\beta = 0.5$ as we find $\beta = 0.50 \pm 0.01$. For R. S. we get the classical value of from $T_c - T = 2.5 \text{K}$ to $0.7 \text{K}$. Below these regions the value of $\beta$ decreases for both crystals. For T. G. S. we have calculated the contribution of the electric field to the polarization but it gives at $T_c - T = 10^{-2} \text{K}$ only few percents higher value than the extrapolation with $\beta = 0.5$. The difference between the measured and calculated value of polarization exceeds the experimental error in the region below $T_c - T = 0.05 \text{K}$.

**Acknowledgment.** — This research was supported by Boris Kidric Foundation.

**References**
